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TECHNICAL REPORT
NATICK/TR-94/011

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FAMILY OF PACKAGED WATER/ PACKAGED WATER SYSTEM

By
Diane M. Wood

March 1994

FINAL REPORT
December 1991 - October 1993

UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK , MASSACHUSETTS 01760-5000

SUSTAINABILITY DIRECTORATE

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The purpose of this project was to determine the feasibility of and a method to package potable water on the battlefield for use by the individual soldier or small groups of soldiers, in support of the airland battle concept. Water packaged in expendable containers will increase the capability to adequately distribute potable water from the supply point to the soldier in the field, thus reducing the dependency on host-nation bottled water. In accordance with a typical Nondevelopmental Item (NDI) approach, a vertical form/fill/seal machine was purchased for evaluation. The focus of the program was redirected, by the Combat Developer, from small individual packages of water to larger containers. As a result of this change in requirements, US Army Natick Research, Development and Engineering Center suspended developmental efforts.

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FAMILY OF PACKAGED WATER/PACKAGED WATER SYSTEM

SUMMARY

The purpose of this project was to determine the feasibility and method of packaging potable water on the battlefield for use by the individual soldier or small groups of soldiers, in support of the airland battle concept. Water packaged in expendable containers will increase the capability to adequately distribute potable water from the supply point to the soldier in the field, thus reducing the dependency on host-nation bottled water.

An international market investigation was completed and site visits to users and manufacturers of liquid packaging equipment were conducted. In support of a Study Plan (preliminary effort for a Cost and Operational Effectiveness Analysis) developed by the Quartermaster Center & School, a Front End Analysis was conducted to assess the feasibility of utilizing commercially available liquid packaging equipment for a field-based packaged water system.

In accordance with a typical Nondevelopmental Item (NDI) approach, a vertical form/fill/seal machine, currently being used by the dairy industry, was purchased for test and evaluation.

The focus of the program was redirected, by the Combat Developer, from small (up to 3, or possibly 5 gallons) individual packages of water to larger (1-20 gallons) containers. As a result of this change in requirements, the responsibility for this project was transferred to U.S. Army Belvoir Research Development and Engineering Center, and U.S. Army Natick Research Development and Engineering Center's (Natick) efforts were suspended. This report will outline Natick's efforts to date.

INTRODUCTION

Current Army doctrine specifies supply point distribution as the primary means of providing potable water on the battlefield. However, the Army needs the capability to adequately distribute potable water from the supply point to the individual soldier. Water distribution on a non-linear battlefield must be more responsive to the shorter, fast-paced battle of the future. The current water supply system is not adaptable to unit distribution.

Water distribution currently requires the use of bulk water transport. Bulk water is then progressively broken down into smaller quantities, to include 5-gallon containers, to eventually reach the individual soldier. In the case of maneuver units, several trips must be made each day to supply points to obtain water as the units are not authorized adequate storage for water. The current water containers require constant attention to maintain necessary sanitation standards. This means that the containers must be cleaned and super-chlorinated each time they are put into service. Then, they must be strictly monitored to assure the containers do not become contaminated. These tasks are time consuming and often manpower intensive. This system also requires the use of specialized bulk liquid transfer equipment, such as the 400-gallon water trailer. Use of such equipment is a burden to the units because they must then sanitize and backhaul these large, cumbersome water containers.

A means of packaging water, in expendable pouches, on the battlefield at specific supply points may alleviate these concerns. Additionally, the need for water resupply in expendable containers becomes much greater in a nuclear, biological, or chemical (NBC) environment.

The Draft Mission Needs Statement (MNS),[1] dated December 1991, outlined four potential solutions to ease the distribution problem. These four solutions will be addressed in this report with emphasis on the fourth, utilization of packaging equipment on the battlefield. The bulk of U.S. Army Natick Research, Development & Engineering Center's (Natick's) effort centered around this alternative, and the results are reported herein.

METHODS, ASSUMPTIONS AND PROCEDURES

In light of these battlefield water supply difficulties, an MNS was developed by the U.S. Army Quartermaster Center and School (USAQMC&S) to devise a means to package potable water on the battlefield. Both materiel and non-materiel alternatives were proposed as solutions to this problem. The only non-materiel alternatives were doctrinal in nature (use host nation bottled water or fill existing non-expendable containers and distribute them as bottled water would be distributed). The alternatives outlines in the MNS are as follows:

1. Do Nothing - The present system of reliance on Host Nation bottled water cannot be assured in all regions of the world because it requires

protection of the source, bottling facilities and a secure means of transport by friendly forces. This assumes a safe level of water quality, which is unlikely in many parts of the world.

2. Refill/Recover - Since canteens and 5-gallon containers are non-expendable items, they must be retrieved, sanitized, refilled and redelivered. This alternative is manpower intensive, time consuming and highly inefficient.

3. Reserve Stock - Maintaining adequate reserve stock for contingency purposes throughout the world would introduce a new set of problems. These problems would include shelf life and stock rotation, as well as the logistical burden of assuring that reserve stock remain potable and palatable. This alternative is also manpower intensive.

4. Non Developmental Item (NDI) - Place a piece of commercially available packaging equipment, capable of meeting the requirements set forth in the MNS, onto the battlefield. The MNS outlined basic requirements for both the equipment and the package produced by the NDI equipment. The equipment will be portable enough to be moved by 2-4 people, as a vehicle will not be dedicated to this piece of equipment; airdroppable from treetop height using Low Altitude Parachute Extraction System (LAPES); compatible with the current water purification and distribution system, as well as North Atlantic Treaty Organization (NATO) equipment and methods; and easy to use. The packaging equipment will not increase manpower requirements. It will be easily operated and maintained by water treatment specialists with no additional training. The equipment will be a sealed system which will allow packaging operations to continue in an NBC environment; and be easily sanitized and decontaminated. The package will be flexible, durable and disposable, and the use of degradable materials evaluated. It will reduce the vulnerability to NBC contamination, be compatible with the protective mask drinking system, and provide a 30 day shelf life for the packaged water.

Natick was tasked to pursue this fourth alternative, and established a project entitled the Family of Packaged Water/Packaged Water System (FOPW/PWS). Under Contract DAAK60-92-P-0598, an international market investigation of packaging systems and equipment capable of packaging potable water in unit packs up to 3 gallons was conducted by Food Equipment Consultants of Milford, MA. Site visits to manufacturers and users of the most promising liquid packaging equipment were conducted by the Natick technical team, and a Front End Analysis of the FOPW/PWS was conducted by Mr. Robert J. Russell under Contract DAAL-91-C-0034, Delivery Order 421. Contractor's final reports are on file at Natick.

After evaluation of the data amassed from the above mentioned contracts and site visits, a vertical form/fill/seal machine which closely met the design criteria was purchased from Du Pont, Canada, and installed at Natick for test and evaluation. A second piece of liquid packaging equipment, that also exhibited the potential to meet the requirements, was ordered from General Packaging, Inc. However, this order was canceled when the project was terminated.

RESULTS AND DISCUSSION

Market Investigation The objective was to conduct an international market investigation of packaging systems and equipment capable of packaging potable water in unit packs, up to 3 gallons, on the battlefield. The ability of the commercial market to produce packaging systems and/or equipment operationally suitable for military use was evaluated.

The approach consisted of wide distribution of a letter (Appendix) generally following the guidelines of Natick Memorandum 70-14 [2] and soliciting each addressee's assessment of their ability to provide a field water packaging system using their standard equipment and/or materials. The requirements for the packaging system were contained in an enclosure to the letter and consisted of the major elements of the Draft Mission Need Statement for the Packaged Water System and the Draft Operational and Organizational Plan (O&O) [3]. These requirements were converted and/or further defined into terminology familiar to the packaging industry; for example, the requirement for the package to fit in the pockets of the Battle Dress Uniform (BDU) was converted to 20 fluid ounces in a 4" wide by 6 1/2" high by 1 1/2" deep configuration. Additionally, the requirements were condensed to a single page. The intent of the letter was to encourage sincere consideration and objective, positive responses. The letter's wording was aimed at whether basic systems and current technology are viable, as opposed to composing a presentation of a cost proposal.

Eighty five companies (foreign and domestic), covering a broad spectrum of commercially available equipment were surveyed. These companies were selected from:

a. Thomas Register - Pharmaceutical, Blood Processing Equipment, and Intravenous Equipment Categories

b. Food Processing 1992 Food Processors' Resource Guide

c. The Blue Book 1991/92 of the Food Processing Machinery and Supplies Association

d. Packaging Encyclopedia and Yearbook

e. Personal information and data files of the contractor

f. Sources recommended by the Contracting Officer's Technical Representative (alike Project Officer)

Although not specifically covered in the letter, the assumption was made that water, prior to packaging, would be adequately sterile (potable and palatable) and that the packaging system would not be required to include any water sterilization functions.

Of the 85 companies surveyed for the market investigation there

were 6 survey responses that the contractor considered to be positive. These positive responses all involved one or more of the following package designs and equipment:

a. Four-side or three-side seal with bottom-gusseted pouches using vertical form/fill/seal equipment. Materials would be polymeric laminates of two or more plies.

b. Rectangular drink boxes using vertical form/fill/seal equipment. Materials would be polymer and paperboard laminates with or without an aluminum foil ply.

c. Preformed, four-side seal pouches with a bung/fitment on one pouch face using filling and sealing equipment designed for entry through the fitment. Materials would be polymeric laminates.

Site Visits The objective was to observe liquid packaging equipment, currently being used commercially, to ascertain its potential to package potable water on the battlefield.

The approach consisted of members of the Natick technical team visiting manufacturers or users of liquid packaging equipment to observe and evaluate the equipment in a full-production setting.

Based upon results of the market investigation and subsequent contacts made by the project officer, the team visited two independent dairies that package milk in pouches for institutional use, retail sales, or school lunch programs; and an equipment manufacturer with extensive expertise and experience with liquid packaging equipment. The team noted the following design features and materials:

a. Preformed pouches (97 fluid ounce capacity) with bottom gusset (doy pak style) sealed on a computer controlled, carousel style sealer were filled with evaporated milk for institutional use. Pouch material was a polymeric/aluminum foil laminate consisting of three or more plies. The stand up pouch also featured a nylon pull tab as an easy open feature.

b. Pillow style pouches with lap seals (64 fluid ounce capacity) were produced on a vertical form/fill/seal machine, and filled with pasteurized milk for retail sales. Pouch material was a polymeric laminate with barrier layer.

c. The equipment manufacturer visited was capable of producing a vertical form/fill/seal machine with a positive displacement pump. This equipment can produce a three- or four-side pillow pouch with a capacity in excess of 100 fluid ounces. Pouch material would be a polymeric/aluminum foil trilaminate similar to that used for the Meal-Ready-To-Eat (MRE), since that particular trilaminate has been successfully used in the field since 1983.

Front End Analysis The objective of the analysis was to conduct an initial assessment of the feasibility of utilizing commercially available liquid packaging equipment for a field-based packaged water system to

supplement the current water distribution system [1].

The approach consisted of evaluating the capability of commercially available equipment, as identified by the market investigation and the site visits, to provide a means to package potable on the battlefield. The criteria which served as the basis for the evaluation were the constraints (requirements) listed in the MNS and the Essential Elements of Analysis (EEAs) listed in the Draft Study Plan (DSP) [4], developed by the USAQMC&S in support of the Cost and Operational Effectiveness Analysis (COEA). The MNS constraints and EEAs relate to the following:

MNS	EEA
Health and Safety	Operational effectiveness
Design	Impact on logistics
Water quality	Impact on force structure
Packages and equipment	Impact on productivity
Packaging materials	Impact on training
Operations and maintenance	Impact on safety and health hazards
NATO compatibility	Impact on human factors engineering
Mission requirements	Cost factors

These factors provided the basis for determining which pieces of existing equipment, if any, could potentially meet the expressed need or demonstrate potential to meet the need of packaging potable water on the battlefield for use by individual and small groups of soldiers. The front end analysis prioritized previously identified equipment for future testing under laboratory and field conditions.

Three liquid packaging systems were considered to be feasible options for the FOPW/PWS and were the subject matter for this analysis. The packaging systems, in descending order of potential to meet the need, are as follows:

1. Pre Pak IS-3, Du Pont, Canada - a vertical form/fill/seal machine that produces a pillow style pouch with a lap seal.

2. Food Equipment Manufacturing Corporation (FEMC) - a vertical form/fill/seal machine, with a positive displacement pump, that produces either a three- or four-side pillow pouch.

3. Diehl, Inc. - a carousel-style system that fills and seals preformed doy pak style pouches.

The results of the front end analysis indicated that each of the three systems will require design modifications to meet the MNS and EEA requirements. Additional tests and evaluations (laboratory and/or field) would be necessary to generate data that directly applies to the military environment.

It was determined by the Natick technical team that of the equipment observed during the site visits the Pre Pak IS-3 vertical form/fill/seal

machine from Du Pont, Canada exhibited the greatest potential to meet the requirements for a piece of non-developmental equipment to package potable water on the battlefield. The IS-3 is currently being used by the dairy industry, in both the United States and Canada, to package milk for school lunch programs and retail sales. This piece of equipment was purchased, with minimal engineering design modifications in mind, and delivered to Natick.

At a meeting with the Combat Developer in March 1993 there was discussion that the focus of the FOPW/PWS had been redirected away from providing water in small individual size containers toward providing water in larger containers, up to 20 gallons. The equipment would no longer need to be portable or man-handleable, but will most likely be housed in an ISO (International Standardization Organization) shelter.

There was also discussion on issues that would require doctrinal changes, such as shifting from supply point distribution to unit distribution. Subsequently, the scope of work for the QMC&S contract to conduct the COEA was modified to convert the COEA to a Concept Analysis for the Total Field Support System. The modification also changed the scheduled completion date of the Concept Analysis to 31 May 1994. The concept analysis will define production, storage and packaging requirements; range of package sizes; doctrine, training, leader development, organization, material, and soldier impacts.

At this point, Natick suspended further work on the program by canceling an order for a second potentially acceptable packaging machine, and delaying in-house evaluation of the equipment (Pre Pak IS-3) and packaging materials that had been purchased. Funds were reprogramed within the DoD Food Program, while maintaining a minimal dollar amount in the fiscal year to close out the program and generate a technical report.

Since the IS-3 had been manufactured and delivered to Natick prior to the focus of the program being redirected, it was installed and Natick personnel were trained on its operation and maintenance in May 1993.

The FOPW/PWS program was briefed at the Water Resources Management Action Group steering committee meeting and the Joint Service Field Water Supply Meeting in May and July 1993, respectively. After lengthy discussions at both meetings it was determined by HQDA, Office of the Deputy Chief of Staff for Logistics (HQDA, ODCSLOG) and the USAQMC&S that Natick terminate all efforts in this area, and that upon completion of the concept analysis and an approved Operational Requirements Document (ORD) the status of this program would be reviewed. It was also determined that if the focus of the FOPW/PWS program is to be large (up to 20 gallons) containers that it would not be funded by the DoD Food Program, and that U.S. Army Belvoir Research, Development and Engineering Center (BRDEC) would be the agency responsible for the materiel development with support from Natick, as appropriate.

CONCLUSIONS AND RECOMMENDATIONS

The need to augment the Army's capability to adequately distribute potable water on the battlefield has been established. Four alternative solutions have been offered by the Combat Developer. These alternatives are: To do nothing and rely on our current water supply/distribution methods; to adapt commercial packaged water systems to U.S. Army requirements; to develop the means to fill, deliver, and recover large quantities of canteens and/or 5 gallon containers; or, to keep adequate reserve stocks of bottled/packaged water in the inventory for contingency operations throughout the world.

Natick was tasked to adapt commercial packaged water systems to U.S. Army requirements, as outlined by the Combat Developer. To accomplish this task, Natick established a project and conducted an international market investigation, performed site visits to manufacturers and users of liquid packaging equipment, and completed a front end analysis to assess the feasibility of utilizing commercially available packaging equipment for a field-based packaged water system.

Based upon the results of the above mentioned market investigation, site visits and front end analysis Natick purchased and accepted delivery of a Pre Pak IS-3 from Du Pont, Canada. This vertical form/fill/seal machine is currently being used commercially to package milk in pouches, and exhibited potential to meet the requirements for a piece of non-developmental equipment to package potable water on the battlefield. The intent was to evaluate the IS-3 and, with minor engineering design modifications, adapt it to package potable water on the battlefield for the individual soldier or small groups of soldiers.

However, the focus of the program was redirected from providing water in small individual-size containers toward providing water in larger (up to 20 gallons) containers. A container in excess of 5 gallons no longer directly supports the needs of the individual soldier, and therefore, falls outside of the scope of the DoD Food Program. Funding was redistributed within the DoD Food Program and efforts supporting the FOPW/PWS were suspended pending further guidance from the Combat Developer.

The responsibility for this developmental effort will be transferred to BRDEC, with packaging support, as required, available from Natick.

It is recommended, in the true spirit of teaming, and to utilize the technical expertise of both Centers, that Natick and BRDEC work closely together in this developmental effort to meet the needs of our common customer, the individual soldier. Based on Combat Developer guidance, it may also be potentially feasible that parallel packaged water programs be conducted to support both the individual soldier (Natick) and larger groups of soldiers (BRDEC).

This document reports research undertaken at the US Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-94/011 in the series of reports approved for publication.

REFERENCES

1. U.S. Army Quartermaster Center and School. 1991. Draft Mission Need Statement for the Packaged Water System, Memorandum for Commander, U.S. Army Training and Doctrine Command, ATSM-CDM, Fort Lee, VA.

2. U.S. Army Natick Research, Development and Engineering Center. 1991. Natick Research Development and Engineering Center Market Analysis, Memorandum No. 70-14.

3. U.S. Army Quartermaster Center and School. 1991. Draft System MANPRINT Management Plan (SMMP) and Operational and Organizational (O&O) Plan for the Family of Packaged Water (FOPW), Memorandum for Commander U.S. Army Natick Research, Development and Engineering Center, ASTM-CDM, Fort Lee, VA.

4. U.S. Army Quartermaster Center and School. 1992. Draft Study Plan for the Packaged Water System, Abbreviated Analysis, Department of the Army Headquarters, U.S. Army Training and Doctrine Command, Fort Monroe, VA.

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APPENDIX

FOOD EQUIPMENT CONSULTANTS
12 GLINES AVENUE
MILFORD, MA 01757

February 1, 1992

W. A. Lane, Inc.
998 S. Sierra Way
San Bernardino, CA 92408
Don Lander, Natl Sales Mgr

Gentlemen:

The U. S. Army Natick Research, Development and Engineering Center, Natick, Massachusetts, has engaged the services of **Food Equipment Consultants** to investigate the commercial availability of packaging systems and equipment capable of packaging potable water on the battlefield in disposable unit packs.

To this end, the U. S. Army has defined the need for a system - package and its filling and sealing equipment - to package potable water for distribution through its existing supply channels to the individual soldier in the field. Initial concept visualization has been a flexible container similar to those used for conventional intravenous fluids.

The desired characteristics of the packages and the associated packaging equipment are as indicated on the enclosed data sheet.

We would appreciate receiving catalogs, brochures and/or other pertinent technical data which would indicate the ability of your company to supply the packs and/or equipment as described in the enclosure. For additional information, please contact either Mr. Leo Harlow at (508) 473-4275 or Dr. Ron Lampi at (508) 366-8069. Catalogs and other material should be mailed to Food Equipment Consultants, 12 Glines Avenue, Milford, MA 01757.

Since the Army is anxious to complete this project as soon as possible, a reply by *21 February 1992* would be appreciated.

Sincerely,

LEO J. HARLOW
Consultant

FILE COPY

Enclosure

PACKAGED WATER SYSTEM

NEED

A need exists for the capability to adequately distribute potable water on the battlefield from water supply point to the individual soldier. The water distribution system would permit the use of disposable packaging and allow for faster and more efficient use of transportation assets. Isolated units would not have to periodically contact a central point to replenish water, carry empty containers or leave visible indications of their presence in operational areas.

Packaged water could make up to 100% of the potable water during the deployment phase and from 5 to 10% of total potable water during follow-up phases. The system may also have applications to the needs of other U. S. services and may have international standardization implications.

OPERATIONAL CHARACTERISTICS

A. PACKAGES

1. Must be capable of being carried by the individual soldier and fit in the pockets of the Battle Dress Uniform. This translates to a volume of 20 fluid ounces in a 4" wide by 6-1/2" high by 1-1/2" deep configuration. An oval or cylindrical package of equal volume would be appropriate.

2. Must provide a shelf life of at least 30 days (optimally 90 days), provide a means for consumption compatible with the protective mask drinking system, be durable enough to withstand parachute drops (ideally withstand free-drop from 300 feet), and be disposable by burying. Design has been visualized as similar to that for conventional intravenous fluids.

3. Must be subdued in color to counter visibility vulnerability, and be resistant to NBC contamination. Material itself (or preformed packages) must have a shelf life of at least 5 years. Package must not impart undesirable flavor or odor to its contents.

B. PACKAGE EQUIPMENT

1. Must be capable of packaging 230,000 liters of water per month. Operating parameters are 3 continuous hours per day for a 30-day month and allowing 30 minutes for set-up and 30 minutes for shut-down or disassembly. For a 20 fluid ounce package, this translates to 72 packages per minute.

2. Must be capable of being transported by vehicles organic to U. S. Army water supply units; e.g., 5 ton cargo trucks, 1-1/2 ton trailer (bed size 108" x 74"), or on a palletized load system flatrack. The packaging equipment should be a sealed system, resistant to NBC contamination, and NBC decontamination survivable. Service life will be 10 years.

3. Must be operable at skill levels equal to those capable of operating and maintaining water purification units.

4. Must be compatible and utilize standard Army field generated power (60 cycle, 115 V/240V). System must be operable in basic, hot, and cold climates. Logistics and maintenance support will be accordance with the Army maintenance system using standard Army tools and test equipment.

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